The Impacts of Property Accessibility and Neighborhood Built Environment on Single-Unit and Multi-Unit Residential Property Values

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ABSTRACT

Recent consumer surveys and empirical studies suggest linkages between property accessibility, neighborhood built environment and residential property values. This paper provides a comprehensive study to understand the impacts of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values. It uses a sample of over 4,500 single-unit and 2,300 multi-unit residential properties collected in over 1,800 neighborhoods of Adelaide, Australia. Hedonic house price models are applied to study the similarities and dissimilarities of the impacts of different types of property accessibility (property accessibilities to retail locations, and social and recreational locations by walk, public transit and automobile), neighborhood built environment (land-use mix, residential density and intersection density), and other contributing factors (physical attributes of the property, social and economic characteristics of the neighborhood, and public school district quality) on single-unit and multi-unit residential property values. The model results suggest that planners need to consider land use mix, new social and recreational locations, intersection density, and public transit locations in designing and implementing neighborhood development strategies. They also indicate that investors need to consider the following aspects in developing property investment strategies, including property physical condition, proximity to retail, social, and recreational locations, school district quality, neighborhood development intensity, and residents’ preferred residential property features. Further, the similarities and dissimilarities of the impacts of various contributing factors on single-unit and multi-unit residential property values can be used to aid planners in neighborhood design, and assist investors to make more informed residential property investment decisions.

INTRODUCTION

Over the past few decades, extensive studies have been performed to understand the relationship between residential property values and their contributing factors. Four key categories of contributing factors that impact residential property values have been identified in previous studies (*1*, *2*), including property accessibility, property physical attributes, social and biophysical features of neighborhood environment (which include the neighborhood built environment, and social and economic characteristics of the neighborhood), and public sector factors (taxes and services). Property accessibility quantifies the ability to access different services/opportunities from a property at a micro-scale level. Several studies (*2, 3, 4, 5, 6*) have found that a higher property accessibility can increase residential and commercial property values, as well as provide potential environmental and social benefits. The neighborhood built environment reflects the density, diversity, and design of the neighborhood (*7*). Some studies (*4*, *6*) have concluded that a higher land use mix, an important component of the neighborhood built environment, can potentially reduce single-unit residential property values. However, the aforementioned studies only consider a single mode of accessibility (walk, public transit, or automobile) and for only the single-unit case, and the literature is sparse on understanding the similarities and dissimilarities of the impacts of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values.

The proposed study seeks to provide a comprehensive analysis on the similarities and dissimilarities of the impacts of different types of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values. Six types of accessibilities are considered, including property accessibility to retail stores and social and recreational locations (e.g. parks and open spaces) by walk, public transit, and automobile. Based on the generalized definition of accessibility (*8*), a residential property's accessibility by a certain mode is defined as the ease of accessing different opportunities for activities using that mode. Residential density, intersection density, and a generalized dissimilarity index for land use mix are used to quantify three key aspects of neighborhood built environment, namely density, design, and diversity, respectively. In this study, single-unit residential property refers to an individual, free-standing and unattached residential property. Multi-unit residential properties include both maisonettes and row houses. Maisonette refers to a property that has two or more floors with connected staircases in an apartment building. A row house is defined as a residential property having common walls with other residential properties of similar or identical design.

The remainder of the paper is organized as follows. The next section describes previous studies on understanding the relationship between residential property values and their contributing factors. After that, the methods used to quantify property accessibility and built environment, and the modeling method used to understand the relationship between residential property values and their contributing factors, are described. Then, the data acquisition for the study region, the Adelaide Government Region, Australia, is discussed. Next, the estimated models are discussed and analyzed to provide insights. The last section provides some concluding comments.

LITERATURE

Several studies have been performed to explore the relationship between residential property values and their contributing factors. The next subsection reviews studies focused on understanding the impacts of property accessibility and neighborhood built environment on residential property values. Then, studies related to understanding the relationship between residential property values and other contributing factors are discussed.

Residential Property Values, Property Accessibility and Neighborhood Built Environment

Traditionally, the relationships between property accessibility, neighborhood built environment and residential property values have been studied and explained through a single parameter, namely a property's physical proximity to a city's or region's central business district (CBD) (*9*, *10*, *11*, *12*). Historically, CBDs have been the areas with the greatest accessibility to various activities, the highest density, and most diverse land use (high land use mix). Many studies (*9*, *10*, *11*) have shown that residential property values are inversely proportional to the property's distance to the CBD. It indicates that the shorter the distance to CBD, the higher the property value, and vice versa. These effects have been reduced in some regions due to the introduction of multi-centered urban form (*12*). Hence, many recent studies (*2*, *4*, *5*, *6*, *13*, *14*, *15*, *16*, *17*) introduced different methods to quantify accessibility and neighborhood built environment, and tried to analyze their impacts on residential property values. However, these studies only include a single mode of accessibility; either walk, public transit, or automobile.

Many studies (*2*, *4*, *5*, *6*, *13*, *15*) have shown that property accessibility is an important factor that affects single-unit or multi-unit residential property values. Opportunities and cost of travel are the two most important aspects of property accessibility measurement. Opportunities represent the amount and types of activities that a property can access. Cost of travel can be measured based on the distance or travel time from a property to its potential destinations. In a multimodal context, there are three main reasons why the cost of travel should be measured based on travel time from a property to its potential destinations. First, the cost of travel measured based on distance cannot capture the amount of travel from a property to a potential destination using transit, where a door-to-door transit trip should include walking from the property to the transit stop, time spent in transit, and walking from the transit stop to the destination. For example, the travel distance from a property with good transit access to a park may be the same as that of another property with bad transit access to another park. However, the travel time for the property with good transit access may be significantly shorter than that for the property with bad transit access. This cannot be captured using a distance-based method. Second, the cost of travel measured based on distance cannot capture the impact of congestion on accessibility. For the same travel distance, the travel time between a property and its potential destination can be significantly longer in a congested region than that in an uncongested region. Third, previous studies (*4*, *17*) found that the cost of travel measured based on travel time performs better in terms of capturing the impacts of property accessibility on residential property values compared to the that of travel distance.

The Hansen-gravity accessibility measures and the class of floating catchment methods (FCMs) are the most commonly used robust approaches to capture both components. The FCM is more intuitive to interpret and requires less data to calculate compared to the Hansen-gravity accessibility measures (*6*, *18*). One study (*19*) analyzed the impact of light rail transit on the property values of rental apartment buildings (multi-unit residential properties) using light rail station catchment areas. They found that there exists a positive relationship between light rail station proximity and the rental apartment building value up to a distance of 1.25 miles from the station, using binary measures of (one-quarter mile) distance bands. In addition, they also found other accessibility related variables (e.g. distance to nearest park or supermarket) and neighborhood related variables (e.g. number of persons per household and median household income) have significant impact on multi-unit residential property values. A recent study (*6*) used

Google Maps to measure the travel time between a property and its potential destinations. This addresses the weakness of other measuring methods (e.g. straight line distance, network travel time) by factoring neighborhood topography, physical barriers, street patterns, sidewalk availability and traffic. In addition to improving the property accessibility measurement, it enables a better understanding in terms of the impacts of property accessibility on residential property values. However, few studies have considered different types of property accessibility in terms of different modes of transportation, and their impacts on the values of different property types to compare their potential similarities and dissimilarities.

Several aspects of neighborhood built environment have been studied to analyze their impacts on residential property values. Intersection density, residential density, and land use mix have been identified as the three commonly used measurements to address the three key aspects of neighborhood built environment, namely design, density, and diversity, respectively. Intersection density represents the ratio between number of intersections to the total land area, and residential density is the ratio of population to the total residential land area. A recent study (*20*) summarized the land use-travel literature and identified three types of land use mix measures, including relative balance between jobs and population within subareas of a region, the diversity of land uses within subareas of a region, and the accessibility of residential uses to nonresidential uses at different locations within a region. Entropy index (*21*), interaction index (*22*), and generalized dissimilarity index (*6*) are three commonly used methods to measure the diversity of land uses within subareas of a region. The generalized dissimilarity index can address the limitation of entropy index by factoring a neighborhood's micro-scale land use variation, and can be applied to all types of land use data, while the interaction index cannot be applied to land use parcels having gaps between them (*6*). Results from empirical studies related to the impacts of different aspects of neighborhood built environment on residential property values are varied and at times contradictory. Some studies (*6*, *14*, *17*) found high land use mix and residential density can decrease single-unit residential property values, while high intersection density can increase single-unit residential property values. Other studies (*10*, *11*) showed that high land use mix, intersection density and residential density can increase single-unit residential property values.

Residential Property Values and Other Contributing Factors

Apart from the aforementioned property accessibility and neighborhood built environment factors, neighborhood social and environment characteristics, public school district quality, and physical attributes of properties are also important factors that affect residential property values.

Household income and household structure are the two important neighborhood social and environment characteristics that impact residential property values. Previous studies (*2*, *4*, *5*, *6*) found that residential properties in neighborhoods with relatively high-income residents are often valued higher. It indicates that higher income households can afford the typically higher property costs. For the average household size, some studies (*4*, *6*) found that households with a relatively large household size may seek residential properties with lower values, as their other living expenses are relatively high.

Some studies (*11*, *23*) also found that public school district quality has a significant impact on residential property values. One study (*23*) examined the quality of 37 different school districts for six metropolitan areas in Ohio. They found that pupil/teacher ratio, expenditure per pupil, and students' test performance are the three most important measures of school quality that impact residential property values.

Property age, property building style, property size, condition of property and number of rooms in property are also found to be important physical attributes of properties that impact residential property values. Most studies (*2*, *4*, *5*, *6*, *13*, *15*) found that as the property condition and number of rooms in the property increase, residential property values also increase. One recent study (*6*) concluded that some types of property building styles can also influence single-unit residential property values. Some studies (*6*, *10*) also found that in urban and mature neighborhoods, older properties are valued higher due to their close proximity to desired activity locations.

The aforementioned studies address neighborhood built environment, physical attributes of the property, social and economic characteristics of the neighborhood, and public school district quality for only the single-unit case, and are further limited to considering only a single mode of accessibility. However, they do not address the potential similarities and dissimilarities of the impacts of different types of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values. In this study, the impacts of six different types of property accessibility (property accessibilities to retail locations, and social and recreational locations by walk, public transit and automobile), neighborhood built environment (land-use mix, residential density and intersection density), and other contributing factors on the values of single-unit and multi-unit residential properties are examined. The potential similarities and dissimilarities of these impacts are captured and analyzed using a large set of empirical data in Adelaide region.

METHODOLOGY

This section describes the methods used to quantify property accessibility and neighborhood built environment. In addition, the model used to analyze the impacts of property accessibility and neighborhood built environment on residential property values is also presented.

Accessibility

A modified FCM method proposed in a previous study (*6*) is used to calculate a property's accessibility to different destinations using different transportation modes. The accessibility (A_{ic}) of property *i* using mode *c* is calculated as follows. Given a property *i*, search all the intended destinations *j* (e.g. retail locations) within a threshold value of travel time (t_{0c}) using a mode *c*. Then,

$$A_{ic} = \sum_{j \in (t_{ijc} \leq t_{0c})} S_j f(t_{ijc}, t_{0c}) \tag{1}$$

where t_{ijc} is the travel time between *i* and *j* using mode *c*, $f(t_{ijc}, t_{0c})$ represents the travel time decay function, and S_j is the weight of destination *j*. The travel time decay function is used to capture the inverse relationship between travel time and accessibility, that is, as the travel time increases, the accessibility decreases. A kernel function (KD) is used to represent the travel time decay function as follows (*24*):

$$\begin{cases} f\left(t_{ijc}, t_{0c}\right) = \dfrac{3}{4}\left[1 - \left(\dfrac{t_{ijc}}{t_{0c}}\right)^2\right], if\ t_{ijc} \leq t_{0c} \\ f\left(t_{ijc}, t_{0c}\right) = 0\ if\ t_{ijc} > t_{0c} \end{cases} \tag{2}$$

Six types of property accessibility were considered, including property accessibilities to social and recreational locations and retail locations by three transportation modes (walk, public transit, and automobile). Threshold travel times ranging from 5 to 60 minutes, with 5-minute increments, are tested for each type of accessibility. The threshold travel time implies that only destinations within this threshold value are considered accessible from a property, and those outside are not. The weights of destinations are assumed to be proportional to their physical areas.

Land Use Mix

To quantify land use mix, a key component of neighborhood built environment, a generalized dissimilarity index proposed in a previous study (*6*) is used. The generalized dissimilarity index can address the limitations of other commonly used land use mix quantification methods and also outperforms them in terms of goodness-of-fit and explanatory power. It can be written as (*6*):

$$DIS = \frac{\sum_{i}^{I}\left(\frac{\sum_{ni}^{Ni} X_{ni} * b_{ni})}{\sum_{ni}^{Ni} b_{ni})} * b_i\right)}{B} \tag{3}$$

where *B* is the size of the neighborhood, b_{ni} is the size of a parcel *n* neighboring parcel *i*, *I* is the total number of parcels in the neighborhood, and $X_{ni} = 1$ if land use category of neighboring parcel *n* differs from that of parcel *i* (0 otherwise). For each neighborhood within the study region, its land use mix value calculated using Equation 3 is then normalized to the generalized dissimilarity index value ranging from 0 (no mixed use, single land use) to 100 (all land uses are equally present and well-mixed). The purpose of normalization is to scale the values of land use mix with different orders of magnitude to a value between 0 and 100 (*25*). In this study, the land use parcels are categorized into six types, including residential, commercial, mining/primary production/agricultural, social/recreational, institutional/public service, and vacant.

Model

This study seeks to understand the impacts of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values. Hedonic price models and regression techniques have often been used in previous studies to understand the relationship between residential property values and other contributing factors. The most common model type used for this purpose is the semi-logarithmic specification, and can be written as (*26*):

$$\ln Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_i X_i + \cdots + \beta_k X_k + \varepsilon \tag{4}$$

where *Y* is the residential property value, β_0 is an estimated constant, X_i is an explanatory variable *i*, β_i is the estimation coefficient for variable *i*, and ε is the error term. Given the semi-logarithmic specification of the model, one unit change of a non-indicator explanatory variable (X_i) can result in $(100 \times \beta_i)$ percent change in the dependent variable (*Y*) (*27*), and denotes the elasticity of that variable. For indicator variables (dummy variables), the elasticities (E_i) can be calculated as (*28*):

$$E_i = [\exp(\beta_i) - 1] * 100 \tag{5}$$

DATA ACQUISITION

The section summarizes the data acquisition for the proposed study. The Adelaide metropolitan region, Australia was selected (Figure 1) for the study analysis. It contains 2000 census collection districts (CCDs) located in 16 cities. Each CCD represents a neighborhood, containing about 220 dwellings and 500 people on average. The CBD of the Adelaide metropolitan region is located in Adelaide city. Among them, 143 CCDs located in east of Onkaparinga, center of West Torrens, and east of Port Adelaide (Enfield) and Salisbury, are dedicated to social/recreational or institutional/public service usage without residential properties. Hence, only the remaining CCDs are considered. 4516 single-unit properties (Figure 2 (a)) and 2336 multi-unit properties (Figure 2 (b)) are randomly selected from these CCDs, and represent about one percent of each type of property (Figure 2).

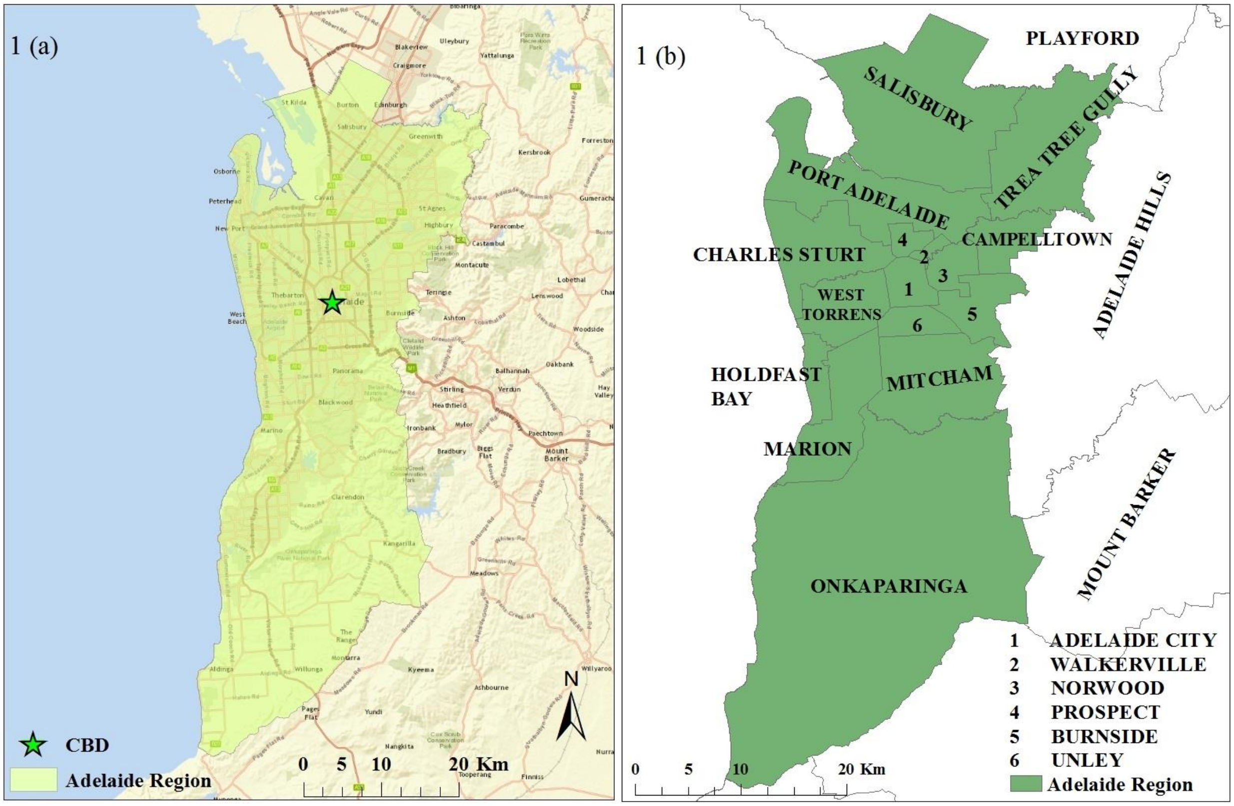

FIGURE 1 (a) CBD location and Adelaide region (green shaded area); (b) cities in or neighboring the Adelaide region.

Five categories of independent variables were considered, including physical attributes of properties, neighborhood built environment, social and economic characteristics of neighborhoods, school district quality, and property accessibility. Based on this, four types of data were collected including census data, land use data, school district information, and the travel time from selected properties to their potential destinations. The census data was collected to capture the social and economic characteristics of neighborhoods, and information of school districts was used to explore the impacts of public school district quality on residential property values. The land use data was used to provide the physical characteristics of single-unit and multi-unit residential properties. The travel time data from selected residential properties to potential destinations using three different modes, including walk, public transit, and automobile, were collected using Google Maps to compute different types of property accessibility.

Table 1 illustrates some aggregated characteristics of the residential properties and their neighborhoods. In terms of physical characteristics of single-unit and multi-unit residential properties, a key observation is that the averages of the residential property value, property size, property age, and number of rooms for single-unit residential properties are larger than those of multi-unit residential properties, respectively (Table 1). The residential property values include both the value of the land and the value of property on the land. Previous studies (*6*, *29*) found that the value of the land and the value of property on the land have a very strong correlation. Thereby, these two values are combined in this study. Another observation is that multi-unit residential properties' property condition is better and style is more diverse (a lower percentage of conventional building style) compared to single-unit residential properties in this study.

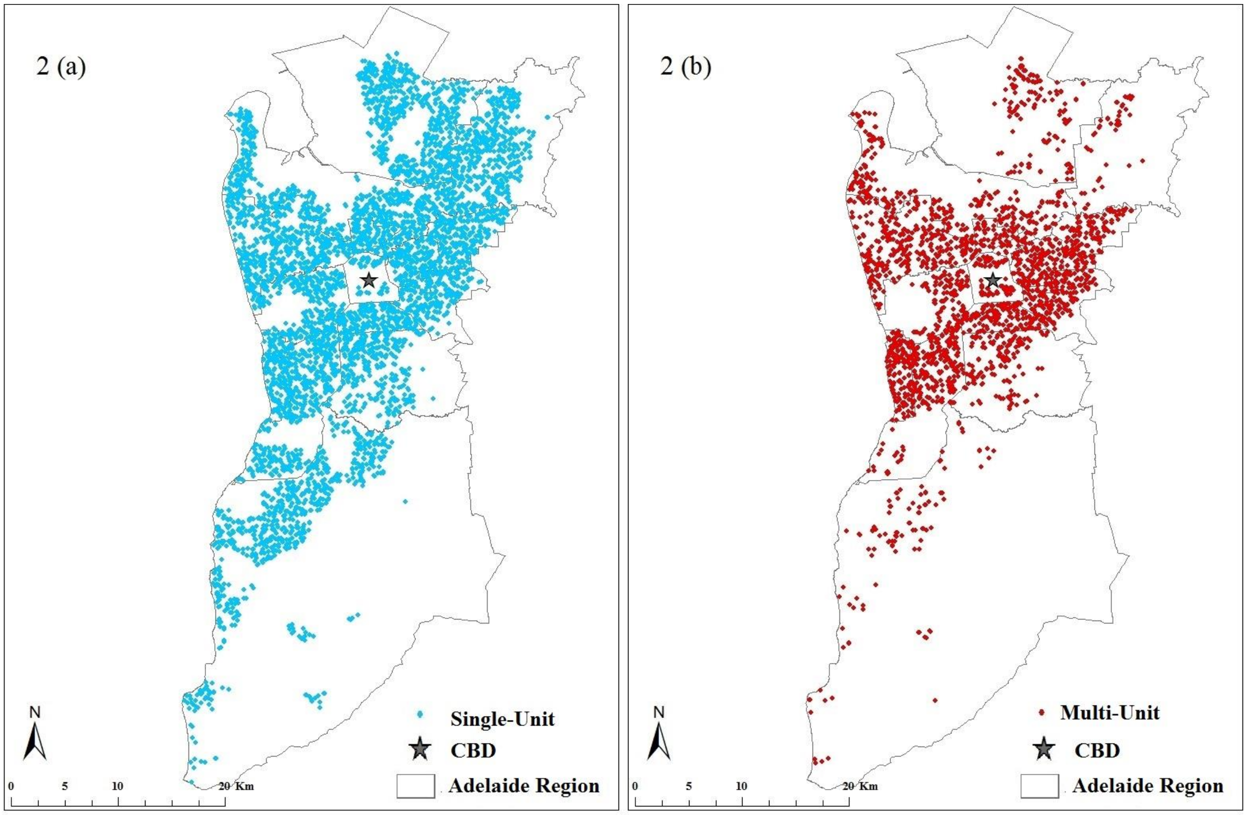

FIGURE 2 (a) Selected single-unit properties; (b) selected multi-unit properties.

Compared to the national average, Adelaide region on average has a higher percentage of population born outside Australia, individual and household income, number of automobiles per dwelling, unemployment rate, and residential density. All three aspects of school district quality are better than their national averages, with lower pupil/teach ratio, higher per student net recurrent income, and higher value of school's index of socio-educational advantage. The school capital expenditure is not available for all schools in the study area. Hence, the net recurrent income per student is used to reflect the financial resources available to a school.

Physical Attributes of Properties and Neighborhood Built Environment

The land use data is obtained from the Land Services Group of the Department of Planning, Transport and Infrastructure of Australia collected in 2009. It represents the most current and complete land use information of the Adelaide Region, including more than 30 different physical attributes (location, property value, age, style, etc.) of each property. Residential density, land use mix, and intersection density for each CCD are also calculated using the land use data.

Social and Economic Characteristics of Neighborhoods and Public School District Quality

The social and economic data for each CCD is acquired from the 2006 census data from the Australia Bureau of Statistics. However, while census data is collected every five years in Australia, only partial data is available for the most recent census (2011). Hence, in this study, the 2006 census data is used.

TABLE 1. Characteristics of Residential Properties Included in the Study

Attribute	**Mean**	**Standard Deviation**
Property attributes		
Property value (Australia dollars in year 2009)		
Single-unit	405682.8	213213.2
Multi-unit	375056.7	202574.1
Property size (equivalent square meters)		
Single-unit	155.47	62.22
Multi-unit	131.93	49.50
Property age at the time of evaluation (in year 2009)		
Single-unit	42.54	29.20
Multi-unit	34.16	33.66
Number of rooms per property		
Single-unit	5.93	1.51
Multi-unit	4.98	1.23
Percentage of property condition is very good or top quality and excellent		
Single-unit	53.55	--
Multi-unit	63.75	--
Percentage of property style is conventional		
Single-unit	50.74	--
Multi-unit	36.90	--
Social and economic characteristics of neighborhoods		
Percentage of population born outside Australia	24.17	6.84
Median individual income per week (converted to Australia dollars in year 2009)	466.53	115.30
Median household income per week (converted to Australia dollars in year 2009)	949.34	304.16
Network distance to CBD (kilometers)	12.94	8.14
Population of neighborhood	518.42	199.61
Number of automobiles per dwelling	1.54	0.30
Percentage of unemployment	5.46	3.33
Neighborhoods built environment		
Residential density (population per square kilometer)	1965.41	869.45
School district quality		
Pupil/teacher ratio	13.04	1.59
Per student net recurrent income (Australia dollars)	12381.33	1979.40
School’s index of socio-educational advantage (ICSEA)	1002.10	74.19

The public school district quality information was acquired from the “My School” website (*30*). It contains students, staff, and financial information of high schools and primary schools in Australia from 2008 to 2014. In the Adelaide region, the majority of public high schools are zoned, but only a small portion of the primary schools are zoned. Hence, only the public high school district quality in year 2009 is included in this study. For each high school district, three measurements were used to quantify the quality of school, including pupil/teacher ratio, per student net recurrent income, and school's index of socio-educational advantage (ICSEA). ICSEA was created by the My School website and is considered as a reliable index that predicts the performance of students on the National Assessment Program – Literacy and Numeracy (NAPLAN) test, with a national average set at 1000. A school with a higher ICSEA indicates its students are more likely to perform better in the NAPLAN test compared to students in a school with a lower ICSEA score. Per student net recurrent income represents the ratio between the financial income of a school and the number of students in that school. Past studies (*23*) suggested that pupil/teacher ratio, financial resources per pupil, and students' test performance are the three important measures of school quality that housing market values. 39 high school zones are included in the study area.

Property Accessibility

Seven different property accessibility types are considered, including, network distance to CBD, walk, public transit and automobile accessibilities to 7873 retail stores (retail shops, restaurants, and personal services), and 1340 social and recreational locations (outdoor arenas, parks, and sports grounds). Different types of accessibility were separated because previous studies (*6*, *31*) indicate that accessibilities to some destinations by some modes have stronger influences on property values compared to other destinations or other modes. The weights assigned for retail stores, and social and recreational locations are quantified by the equivalent size of the property. An assumption was made that a location with larger land equivalent offers greater access to the related activities compared to the same type of destinations with a smaller land size. The locations and sizes of different types of destinations are collected from the database provided by the Land Services Group of the Department of Planning, Transport and Infrastructure of Australia.

The travel time between a property and its potential destinations was measured using the "walking", "transit", and "driving" options on Google Maps between the centroid point of property land parcel and the centroid point of the destination location land parcel. The shortest walking time, public transit travel time (including both walking time from/to the bus stop and time on the bus), and automobile travel time are used. The "walking" option on Google Maps factors neighborhood topography, street patterns, and physical barriers. It can address the limitation of straight-line distance measurements in the Walk Score and other methods (*6*). Under the "transit" option, Google Maps measures travel time under public transit schedules in 2009. The "driving" option measures the travel time under the normal traffic conditions of Adelaide in 2009. These features allow Google Maps to provide reliable travel time information in a region.

ESTIMATION RESULTS

Model estimation results for single-unit and multi-unit residential property values with the 29 independent variables considered are presented in Table 2. The results are presented for the 30-minute threshold travel time for property accessibility. Model estimation results for single-unit residential property values with only statistically significant variables are presented in Table 3, and model estimation results for multi-unit residential property values with only statistically significant variables are shown in Table 4. The dependent variables are the natural logarithm of the evaluated property values for the single-unit and multi-unit residential properties in the tables.

As shown in Table 3, sixteen variables were found to have a statistically significant correlation ($p<0.05$) with the single-unit residential property values, including five variables related to property physical characteristics, one variable related to school district quality, three variables related to social and economic characteristics of the neighborhood, two variables related to neighborhood built environment, and five variables related to property accessibility.

Eighteen variables were found to have a statistically significant correlation ($p<0.05$) with the multi-unit residential property values, including four variables related to property physical characteristics, two variables related to school district quality, three variables related to social and economic characteristics of the neighborhood, three variables related to neighborhood built environment, and six variables related to property accessibility (Table 4).

The next three subsections analyze in detail the similarities and dissimilarities in terms of the correlation of the neighborhood built environment, property accessibility, and other contributing factors, respectively, with the single-unit and multi-unit residential property values.

Neighborhood Built Environment and the Single-Unit and Multi-Unit Residential Property Values

The estimation results for the single-unit residential property values indicate that land use mix has a statistically significant negative correlation with the single-unit residential property values (Table 3), while the estimation results for the multi-unit residential property values indicate that land use mix has a statistically significant positive correlation with the multi-unit residential property values (Table 4). Based on the elasticities, it can be interpreted that a unit increase in land use mix index value from the mean (50.02) can lead to a 3.14% reduction in the single-unit residential property values and a 0.80% increase in the multi-unit residential property values. Previous studies (*6*, *16*) found similar results for single-unit residential property values, that providing a more diverse land use (high land use mix) can potentially lead to lower cost single-unit residential properties. However, none of the previous studies address the impact of land use mix on multi-unit residential property values. The study results indicate that residents of single-unit residential properties and multi-unit residential properties may have different views on large or intense development of commercial, mining/primary production/agricultural, and institutional/public service development (high land use mix) in the neighborhood. This may be because residents of single-unit residential properties focus more on the associated social/environmental costs of these developments, while residents of multi-unit residential properties may value more the convenience of access to different types of activity locations in the neighborhood due to such development.

Another variable found to have a statistically significant correlation with both single-unit residential property values and multi-unit residential property values is intersection density. The estimation results suggest that as intersection density increases by one intersection per square meter from the mean (34.52 per square meter), the single-unit residential property values decrease by 1.31% (Table 3) and the multi-unit residential property values increase by 0.59% (Table 4). A plausible explanation is that residents of single-unit residential properties may value more the negative impacts of high intersection density (e.g. indicative of more traffic and congestion), while residents of multi-unit residential properties may focus more on the positive impacts of high intersection density (e.g. slower traffic and more pedestrian crossing opportunities).

TABLE 2 Estimation Results with all Independent Variables included (the Bolded Numbers Indicate that the Corresponding Variable has a Statistically Significant Correlation with Residential Property Values)

Variables	Estimate (single-unit)	Estimate (multi-unit)
Intercept	11.82841	10.732
Property physical characteristics		
The age of the property in year 2009	**0.00066**	**-0.00062**
Property size (equivalent square meters)	**0.00318**	**0.00316**
Conventional: 1 if the building style is conventional, 0 otherwise	**0.02658**	**-0.02279**
Good condition: 1 if the property condition is “very good” or “top quality and excellent”, 0 otherwise	**0.03241**	**0.03201**
Room: number of rooms	**0.01123**	0.00322
How many years since the property were last sold	-0.00018	0.00006
Stories: number of stories for the property	0.00017	0.00009
Modifications: number of modifications made	0.00020	0.00031
School district quality		
ICSEA	**0.00009**	**0.00030**
Per student net recurrent income	-0.00001	-0.00004
Pupil/teach ratio	0.00031	**-0.00009**
Social economic characteristics of the neighborhood		
Percentage of population born outside Australia	**-0.00256**	**-0.00171**
Median household income per week (Australia dollars in year 2009)	**0.00006**	**0.00035**
Median individual income per week (Australia dollars in year 2009)	0.00017	0.00021
Average household size	**-0.09499**	**-0.02310**
Percentage of population under 25	0.00537	0.00122
Percentage of population over 64	0.00430	0.00032
Percentage of unmarried population	-0.00005	-0.00001
Unemployment rate	-0.00119	-0.00053
Neighborhood built environment		
Land use mix	**-0.02577**	**0.00821**
Intersection density	**-0.00786**	**0.00596**
Residential density	0.00003	**0.00009**
Property accessibility		
Distance to CBD (kilometers)	**-0.00730**	**-0.01289**
Transit accessibility to social and recreational locations	**0.00085**	**0.00068**
Transit accessibility to retail locations	-0.00013	**0.00015**
Automobile accessibility to social and recreational locations	**0.00253**	**0.00301**
Automobile accessibility to retail locations	0.00026	-0.00020
Walk accessibility to social and recreational locations	**0.00202**	**0.00254**
Walk accessibility to retail locations	**-0.00048**	**0.00068**

TABLE 3 Estimation Results for Single-Unit Residential Property Values

Variable	Estimate	t-Statistic
Intercept	11.88203	155.901
Property physical characteristics		
The age of the property in year 2009	0.00069	9.728
Property size (equivalent square meters)	0.00323	51.001
Conventional: 1 if the building style is conventional, 0 otherwise	0.02638	4.924
Good condition: 1 if the property condition is “very good” or “top quality and excellent”, 0 otherwise	0.03221	5.640
Room: number of rooms	0.01148	4.823
School district quality		
ICSEA	0.00016	2.920
Social and economic characteristics of the neighborhood		
Percentage of population born outside Australia	-0.00310	-7.003
Median household income per week (Australia dollars in year 2009)	0.00014	6.198
Average household size	-0.10028	-5.569
Neighborhood built environment		
Land use mix	-0.03144	-2.011
Intersection density	-0.01311	-3.674
Property accessibility		
Distance to CBD (kilometers)	-0.00728	-15.897
Transit accessibility to social and recreational locations with a threshold travel time of 25 minutes	0.00086	2.439
Automobile accessibility to social and recreational locations with a threshold travel time of 25 minutes	0.00251	8.084
Walk accessibility to social and recreational locations with a threshold travel time of 30 minutes	0.00206	4.722
Walk accessibility to retail locations with a threshold travel time of 25 minutes	-0.00072	-3.670
Summary statistics		
Number of observations	4516	
Adjusted R^2	0.809	

Residential density was found to have a statistically significant correlation with multi-unit residential property values, but was not found to have a statistically significant correlation with single-unit residential property values. Some past studies (*5*, *9*) found that residential density has a negative impact on single-unit residential property values. The estimation results suggest that if residential density increases by one person per residential square meter, the multi-unit residential property values will increase by 0.09%. This is because residents in multi-unit residential properties may have a positive view of dense urban form (high residential density). It could also reflect other unobserved neighborhood characteristics associated with dense urban form, including better urban service and higher presence of public services.

TABLE 4 Estimation Results for Multi-Unit Residential Property Values

Variable	Estimate	t-Statistic
Intercept	10.6833	113.945
Property physical characteristics		
The age of the property in year 2009	-0.00060	-8.696
Property size (equivalent square meters)	0.00307	50.388
Conventional: 1 if the building style is conventional, 0 otherwise	-0.02258	-4.555
Good condition: 1 if the property condition is “very good” or “top quality and excellent”, 0 otherwise	0.03172	5.890
School district quality		
ICSEA	0.00028	3.498
Pupil/teacher ratio	-0.00007	-3.455
Social and economic characteristics of the neighborhood		
Percentage of population born outside Australia	-0.00162	-3.289
Median household income per week (Australia dollars in year 2009)	0.00030	7.640
Average household size	-0.02200	-3.299
Neighborhood built environment		
Land use mix	0.00799	5.496
Intersection density	0.00590	8.222
Residential density	0.00009	6.726
Property accessibility		
Distance to CBD (kilometers)	-0.01110	-13.698
Transit accessibility to social and recreational locations with a threshold travel time of 35 minutes	0.00090	2.747
Transit accessibility to retail locations with a threshold travel time of 25 minutes	0.00013	4.532
Automobile accessibility to social and recreational locations with a threshold travel time of 30 minutes	0.00277	8.950
Walk accessibility to social and recreational locations with a threshold travel time of 35 minutes	0.00232	5.455
Walk accessibility to retail locations with a threshold travel time of 25 minutes	0.00065	2.923
Summary statistics		
Number of observations	2336	
Adjusted R^2	0.801	

Property Accessibility and the Single-Unit and Multi-Unit Residential Property Values

73 different variables related to property accessibilities were considered, including network distance to CBD, and property accessibility to social and recreational locations and retail locations by three modes, namely walk, transit and automobile with twelve threshold travel times (ranging from 5 to 60 minutes, with 5-minute increments).

To analyze the impact of different selected threshold travel times on estimation results, 73 hedonic price models each were created for estimating single-unit and multi-unit residential property values. The first model is the base model and includes four types of independent variables, property physical characteristics, school district quality, social and economic characteristics of the neighborhood, and neighborhood built environment. Other models were created to compare the performance of each threshold travel time for each type of property accessibility. Each model contains the same independent variables as the base model, as well as one type of property accessibility with one threshold travel time. To compare different model results, adjusted R^2 is used to interpret the proportion of total variance explained by independent variables (*32*). A higher adjusted R^2 value implies that the collection of independent variables accounts for a higher percentage of the uncertainty or variation in the single-unit or multi-unit residential property values.

The results show that variables related to property accessibility to social and recreation locations using walk, transit and automobile with only a threshold travel time equal to or lower than 35, 40, and 45 minutes, respectively, have a statistically significant and positive correlation with both single-unit and multi-unit residential property values. In addition, the estimation results also suggest that when the threshold travel time is 25, 25, and 30 minutes, respectively, for walk, transit and automobile, the corresponding adjusted R^2 is the largest among the twelve tested threshold travel times for estimating single-unit residential property values; the corresponding threshold travel times are 30, 35, and 35 minutes in the multi-unit context. These threshold travel times are presented in Tables 3 and 4. The results illustrate the importance of relatively high property accessibilities to social and recreational locations for the investment strategies of investors. They also suggest that different threshold travel times should be considered for different types of property accessibility to understand their specific impacts on single-unit and multi-unit residential property values.

Walk accessibility to retail locations with a threshold travel time equal to or lower than 30 minutes was found to be negatively correlated with single-unit residential property values, but was found to be positively correlated for multi-unit properties. The results also suggest that when the threshold travel time is 25 minutes, the corresponding adjusted R^2 is the largest among the twelve tested threshold travel times for both single-unit and multi-unit residential property values. Transit accessibility to retail locations with a threshold travel time equal to or lower than 35 minutes was found to be positively correlated with multi-unit residential property values, but no statistically significant correlation was found for single-unit properties for any of the threshold travel times. When the threshold travel time is 25 minutes, the corresponding adjusted R^2 is the largest for estimating multi-unit residential property values. Automobile accessibility to retail locations was not found to have a statistically significant correlation with either single-unit or multi-unit residential property values with any threshold travel times. This indicates that residents of single-unit residential properties may have a negative perspective towards retail locations near their residential properties due to potential social/environment costs (e.g. congestion, noise pollution), while residents of multi-unit residential properties may prefer retail locations near them due to better convenience of retail access.

Network distance to CBD was found to have a statistically significant correlation with both single-unit and multi-unit residential property values (Tables 3 and 4). The estimation results suggest that with a one-kilometer increase of network distance to CBD, single-unit and multi-unit residential property values decrease by 0.73% and 1.04%, respectively. Several previous studies (*10*, *11*) also found similar correlation in other metropolitan areas (e.g. London). A possible explanation is that residential properties further from CBDs may have higher associated transportation and convenience costs due to their remoteness. Another is that for a mono centric city like Adelaide, most of the employment is concentrated in the CBD and health services and high quality public schools are located closer to the CBD. Hence, the demand for such properties reduces, which leads to the decrease in residential property values.

Other Contributing Factors and the Single-Unit and Multi-Unit Residential Property Values

Twenty-six independent variables related to the physical characteristics of residential properties were considered, including size, number of rooms, wall and roof materials, property age at the time of evaluation, property conditions, and style of property. Some of the variables are presented in Table 2. Five physical characteristics, including the age of the property in year 2009, property size (equivalent square meters), if property condition is "very good" or "top quality and excellent", property style if it is conventional building, and number of rooms, were found to have a statistically significant correlation with single-unit residential property values. Four of them (except for number of rooms) were found to have a statistically significant correlation with multi-unit residential property values. The condition of properties was evaluated based on an eight-point Likert scale, from "just habitable" to "top quality and excellent". The results show that if the property condition is "very good" or "top quality and excellent", the single-unit and multi-unit residential property values increase by 3.22% and 3.17%, respectively. It indicates that both types of residential properties are valued higher if they received good maintenance suggested by their "very good" or "top quality and excellent" condition.

The conventional building property style was found to have a statistically significant correlation with both single-unit and multi-unit residential property values. The results show that if the property style is conventional, single-unit residential property values increase by 2.64%, while multi-unit residential property values decrease by 2.26%. The conventional building style, one of the 41 property styles in the sample, is the most common building style for both single-unit and multi-unit properties in the sample. But a much larger percentage of single-unit residential properties has the conventional style (50.74%) compared to the percentage of multi-unit residential properties (36.90%). These suggest that the conventional building style may be a preferred style for single-unit properties in Adelaide region, while an unpopular style for multi-unit properties in Adelaide region.

The age of the property in year 2009 (time of the evaluation) was found to be positively correlated with single-unit residential property values, while negatively correlated with multi-unit residential property values. The results indicate that if the property age increases by one year, single-unit residential property values increase by 0.07%, while multi-unit residential property values decreases by 0.06%. This could be because residents of single-unit residential properties may prefer properties of mature neighborhoods in urban areas, while residents of multi-unit residential properties may prefer relatively new neighborhoods.

Number of rooms was found to be positively correlated with single-unit residential property values, but was not found to have a statistically significant correlation with multi-unit residential property values. If the number of rooms in a single-unit residential property increases by one, its property value increases by 1.15%. The results show that for a given single-unit residential property in square meters, dividing that space into more rooms can increase its property value. It also indicates that residents in single-unit residential properties prefer to have more rooms in their property.

Another observation is that the property size (equivalent area) has a statistically significant positive correlation with both single-unit and multi-unit residential property values. The equivalent area of a property represents the weighted total area of a property based on its purpose and construction type. This indicates that a relatively large residential property would be valued higher in the market for both single-unit and multi-unit residential properties.

A school's index of socio-educational advantage (ICSEA) was found to be positively correlated with single-unit and multi-unit residential property values. If the school district's ICSEA increases by one from the mean (1002.10), single-unit and multi-unit residential property values can increase by 0.02% and 0.03%, respectively. Pupil/teacher ratio was found to have a negative correlation with multi-unit residential property values, but was not found to have a statistically significant correlation with single-unit residential property values. If the school district's pupil/teacher ratio increases by one from the mean (13.04), the multi-unit residential property values can decrease by 0.01%. These indicate that a better school district quality in terms of higher student performance and more educational resources (low pupil/teacher ratio) can potentially increase both single-unit and multi-unit residential property values.

Three social and economic variables at the CCD level were found to have a statistically significant correlation with both single-unit and multi-unit residential property values. The percentage of population born outside Australia was negatively correlated with single-unit and multi-unit residential property values. Previous studies (*6*, *26*) suggest that neighborhoods with a high percentage of population born outside Australia may have relatively bad urban services. Hence, the single-unit and multi-unit residential property values may decrease.

Another observation is that the median household income per week is positively correlated with both single-unit and multi-unit residential property values; similar results were also found in a previous study (*19*) for multi-unit properties. This could be because neighborhoods with more high-income households can imply greater affordability of higher-valued residential properties.

Average household size was found to be negatively correlated with both single-unit and multi-unit residential property values, confirming the trend for multi-unit properties in (*19*). It indicates that households with a relatively large household size may seek residential properties with lower values, as their other living expenses are relatively high (*4*, *6*).

CONCLUDING COMMENTS

This study aims to understand the similarities and dissimilarities of the impacts of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values. Previous studies on the impacts of property accessibility and neighborhood built environment on residential property values are limited in terms of the property accessibility types and property types included. To address these limitations, six types of property accessibility were considered, including property accessibilities to retail locations, and social and recreational locations by walk, public transit and automobile. The similarities and dissimilarities of the impacts of property accessibility, neighborhood built environment, and other contributing factors on single-unit and multi-unit residential property values were analyzed using a large set of empirical data in the Adelaide region.

Sixteen variables were found to have a statistically significant correlation with the single-unit residential property values, including five variables related to property physical characteristics, one variable related to school district quality, three variables related to social and economic characteristics of the neighborhood, two variables related to neighborhood built environment, and five variables related to property accessibility. Eighteen variables were found to have a statistically significant correlation with the multi-unit residential property values, including four variables related to property physical characteristics, two variables related to school district quality, three variables related to social and economic characteristics of the neighborhood, three variables related to neighborhood built environment, and six variables related to property accessibility.

As illustrated by Tables 3 and 4, property accessibility and neighborhood built environment have some similar and some dissimilar impacts on single-unit and multi-unit residential property values. Some features of property accessibility such as distance to central business district, transit accessibility, automobile accessibility, and walk accessibility to social and recreational locations have similar impacts on single-unit and multi-unit residential property values. Some features of property accessibility and neighborhood built environment in terms of land use mix, intersection density, and walk accessibility to retail locations have different impacts on single-unit and multi-unit residential property values. Other features of property accessibility and neighborhood built environment such as transit accessibility to retail locations and residential density are significantly correlated with multi-unit residential property values, but not correlated with single-unit residential property values. These results suggest that both single-unit and multi-unit residential property values are higher in neighborhoods with social and recreational locations in close proximity (high property accessibility to social and recreational locations by walk, public transit, and automobile). They also indicate that single-unit residential property values are higher in homogeneous residential neighborhoods (low land use mix) without dense road network (low intersection density) and large or intense retail development in close proximity (low walk accessibility to retail locations), while multi-unit residential property values are higher for more diverse neighborhoods (high land use mix), with dense urban form (high residential density and intersection density) and with convenient access to retail locations (high walk accessibility to retail locations).

This study suggests that the following factors should be considered by planners to design neighborhoods by addressing the similarities and dissimilarities in terms of impacts for single-unit and multi-unit residential properties: (i) intense development (high land use mix) in neighborhoods with predominantly single-unit residential properties should be scaled to fit the neighborhoods size; (ii) choice of new social and recreational locations should be carefully made, as they should be beneficial to various residential properties in the neighborhood (high property accessibility to social and recreational locations by walk, public transit, and automobile); (iii) dense urban form (high intersection density) should be avoided in neighborhoods with predominantly single-unit residential properties, but encouraged in neighborhoods with predominantly multi-unit residential properties; and (iv) residents in multi-unit residential properties may have a higher dependency on public transit compared to single-unit residential properties.

The study also indicates that the following aspects of single-unit and multi-unit residential properties and the associated neighborhood characteristics can assist the property investment strategies of investors: (i) maintaining the physical condition of both types of properties can potentially increase property values; (ii) investing in single-unit and multi-unit residential properties located in good school districts and/or with close proximities and easy access to social and recreational locations; (iii) investing in neighborhoods with high household income; (iv) avoiding investment in single-unit residential properties in neighborhoods with dense development (high land use mix), dense road network (high intersection density), and/or residential density, but investing in multi-unit residential properties in those neighborhoods; (v) understanding residents' preferences of residential property physical characteristics, such as property style, age, and number of rooms; and (vi) avoiding investment in single-unit residential properties with close proximity to retail locations, but doing so for multi-unit residential properties.

The various findings and insights provided in this study can be used to assist planners to effectively design and implement neighborhood development strategies so that the potential impacts on single-unit and multi-unit residential property values in those neighborhoods can be factored. Property investors can also utilize these findings and insights to make more informed residential property investment decisions related to single-unit and multi-unit residential property values.

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